

NODULATION CHARACTERISTICS OF SOME OF THE FORAGE AND BROWSE LEGUMES

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ABSTRACT

Nodulation was studied in 93 species within 25 genera used, or with potential for forage and browse. All the species in subfamilies Mimosoideae and Papilionoideae were nodulated. Nodules were not observed in all *Bauhinia* spp. in subfamily Caesalpinoideae. Nodules in most taxa were mainly distributed on the crown region of the primary root. The crown nodulation coupled with abundant leghaemoglobin, indicates the effectiveness of these nodules. Our next step is to test most promising legume species for pasture management and forage quality. Top pasture management blended with good animal husbandry may result in the improvement of the livestock industry.

KEY WORDS: Forage, browse, legumes, nodulation, taxonomy, livestock production

INTRODUCTION

In Pakistan, depending on the region, grazing grasses and legumes is an important practice like traditional feeding of freshly cut fodder (Dawson 1987; Rasheed & Athar 1997). The fertility return from animal excreta under grazing can be highly significant, especially in grass/legume systems in which the nitrogen cycle under grazing assumes considerable importance. Nitrogen fixation by nodulated forage and browse legumes can increase productivity of rangelands and marginal croplands. Nodulated legumes are not only self sustaining in their nitrogen requirement but they also add substantial amounts of nitrogen to the soil. Little is known about the yield, plant growth and

nitrogen fixation by indigenous and introduced forage legumes in Pakistan. Most studies on nitrogen fixation pertain to annual forage legume crops (Mohammad & Qamar 1988; Athar & Johnson 1996). Information about other forage legumes or their rhizobia is very limited in Pakistan. Even a comprehensive listing of forage legumes and their nodulating ability is not available. The present study was conducted to document potential forage and browse legumes of Pakistan with reference to their nodulating ability.

MATERIALS AND METHODS

Legume species growing under natural conditions were surveyed for their nodulating ability from Pakistan and Azad Kashmir. Wild legumes were examined under natural habitat while legumes of agricultural importance were observed from the cultivated fields. Most legumes examined included herbs, shrubs, and vines. Introduced legumes were studied in field trials of the Pakistan Agricultural Research Council and provincial forest departments. Some of the legumes which are primarily cultivated for their grain production also provide a good source of browse after harvesting the crop. Likewise, some tree legumes traditionally used for shade, timber, and fuel wood also hold promise for potential forage production (Brewbaker 1985). These kinds of grain and tree legumes were also included in the list. Nodules were distinguished from other kinds of morphological modifications or root malformation, and nodulation data were recorded. Legumes were identified by the specimens collected from the mature plants. The nomenclature and tribal classification are as described by Kirkbride (1986). Author citations are quoted following instructions of Brummitt & Powell (1992) as endorsed by the International Working Group on Taxonomy Database for Plant Science (TDWG).

RESULTS AND DISCUSSION

Table 1 gives results of 93 species within 25 genera distributed in twelve tribes of subfamilies Caesalpinioideae, Mimosoideae, and Papilionoideae. The nodules observed in these species confirmed earlier reports (Aguilar, *et al.* 1994; Allen & Allen 1981; Athar 1996a, 1996b, 1997; Brewbaker 1985; Faria, *et al.* 1994; Mahmood & Iqbal 1994; Subramaniam & Babu 1994). All the species in subfamilies Mimosoideae and Papilionoideae were nodulated. Nodules were not observed in all *Bauhinia* spp. in the subfamily Caesalpinioideae. Lack of nodulation has been reported in Caesalpinioideae (Allen & Allen 1981; Athar 1997; Faria, *et al.* 1994; Mahmood & Iqbal 1994).

Nodules in most of the taxa were mainly distributed on the crown region of the primary root. Nodule morphology in Papilionoideae and Mimosoideae coincided very much with the description of Athar (1996a), Corby (1988), and Mahmood & Iqbal (1994). Nodules varied from semi-globose to globose with streaked or smoothed surfaces, to elongated and branched forms with projections into finger-like or fan-shaped structures (Table 1). They occurred singly or as lobed structures. Nodules

were mostly pink or brown with reddish interiors. The crown nodulation coupled with abundant leghaemoglobin indicates the effectiveness of these nodules.

The use of naturally occurring browse species is a vital component of livestock production systems in many regions of the world. Tree leaves and pods form a natural part of the diet of many ruminant species and have been used traditionally as a source of forage for domesticated livestock in Asia, Africa, and the Pacific (Norton 1994). Tree legumes not only provide feed for ruminants, there are also reports of their inclusion in the diets of fish and poultry. The leaves, stems, and fruits may be used for grazing either as a complete food or as a supplement to other feed. In Pakistan, studies are needed on relative productivity from grazing legumes under intensive management in both the rainfed and irrigated conditions (Dawson 1987; Rasheed & Athar 1997). Such studies should focus on exploring special purpose forage legumes (Rumbaugh 1988), comparative production and feasibility of grazed and green-chop system of pasture management (Puckridge & French 1983). Top pasture management blended with good animal husbandry may result in the improvement of livestock industry. Our next step is to test most promising legume species for pasture management and forage quality. Some of the species will also be evaluated for their regeneration ability under periodic cereal cropping systems. The integration of livestock (sheep and/or cattle) will be necessary to optimize land use, grain and meat/fibre outputs, and nitrogen cycling. Grazing during the growing season enhances the establishment and persistence of legume components. Also, proper grazing management can particularly control undesirable weeds, optimizing seed production, and increased nitrogen cycling.

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Table 1. Nodulation characteristics of some of the forage and browse legumes.

| Legume Species ¹ | Type ² | Forage value ³ | Nodule | | |
|--|-------------------|---------------------------|------------------------|------------|-----------|
| | | | Frequency ⁴ | Color | Shape |
| Mimosoideae | | | | | |
| Acacieae | | | | | |
| <i>Acacia albida</i> Del. | TC | * | + | Brown | Elongated |
| <i>A. farnesiana</i> (L.) Willd. | TC | * | + | Brown | Elongated |
| <i>A. leucophloea</i> (Roxb.) Willd. | TC | * | + | Brown | Elongated |
| <i>A. nilotica</i> (L.) Del. | TC | ** | + | Dark brown | Elongated |
| <i>A. senegal</i> (L.) Willd. | TW | ** | + | Brown | Elongated |
| Ingeae | | | | | |
| <i>Albizia julibrassin</i> Durazz. | TC | * | + | Brown | Globose |
| <i>A. lebeck</i> (L.) Benth. | TC | * | + | Brown | Globose |
| <i>A. lophantha</i> Willd. | TC | * | + | Brown | Elongated |
| <i>Pithecellobium dulce</i> (Roxb.) Benth. | TC | * | + | Brown | Elongated |
| Mimoseae | | | | | |
| <i>Leucaena leucocephala</i> (Lam.) de Wit | TC | *** | +++ | Pink | Elongated |
| <i>Prosopis cineraria</i> (L.) Druce | TC | * | + | Pink | Globose |
| <i>P. glandulosa</i> Torr. | TW | * | + | Pink | Globose |
| <i>P. juliflora</i> (Swartz) DC. | TW | * | + | Pink | Globose |
| <i>P. farcta</i> (Banks & Sol.) Macbride | TW | * | + | Brown | Globose |
| <i>Faidherbia albida</i> Del. | TC | * | + | Dark brown | Elongated |
| CAESALPINIOIDEAE | | | | | |
| Cercideae | | | | | |
| <i>Bauhinia purpurea</i> L. | TC | * | - | - | - |
| <i>B. racemosa</i> Lam. | TC | * | - | - | - |
| <i>B. variegata</i> L. | TC | * | - | - | - |
| PAPILIONOIDEAE | | | | | |
| Aeschynomeneae | | | | | |
| <i>Arachis hypogaea</i> L. | HC | *** | +++ | Pink | Globose |

| | | | | | |
|---|-----|-----|-----|--------------|--------------|
| Cicereae | | | | | |
| <i>Cicer arietinum</i> L. | HC | *** | ++ | Pink | Elongated |
| | | | | | |
| Indigofereae | | | | | |
| <i>Cyamopsis tetragonoloba</i> (L.) Taub. | SC | *** | ++ | Light pink | Semi-globose |
| | | | | | |
| Loteae | | | | | |
| <i>Lotus corniculatus</i> L. | HW | *** | +++ | Pink | Elongated |
| | | | | | |
| Phaseoleae | | | | | |
| <i>Cajanus cajan</i> (L.) Millsp. | STC | * | ++ | Light pink | Elongated |
| <i>Glycine max</i> (L.) Merr. | HC | * | +++ | Whitish pink | Globose |
| <i>Lablab purpureus</i> (L.) Sweet | HC | * | +++ | Pink | Globose |
| <i>Macropitium atropurpureum</i> (DC.) Urb. | HC | * | +++ | Whitish pink | Globose |
| <i>M. lathyroides</i> (L.) Urb. | HC | * | ++ | White | Semi-globose |
| <i>Phaseolus coccineus</i> L. | HC | * | +++ | White | Semi-globose |
| <i>P. lunatus</i> L. | HC | * | ++ | Whitish pink | Globose |
| <i>P. vulgaris</i> L. | HC | * | +++ | Whitish pink | Globose |
| <i>Vigna aconitifolia</i> (Jacq.) Marechal. | HC | * | ++ | Pink | Globose |
| <i>V. mungo</i> (L.) Hepper | HC | * | +++ | Pink | Globose |
| <i>V. radiata</i> (L.) Wilczek. | HC | * | ++ | Pink | Globose |
| <i>V. unguiculata</i> (L.) Walp. | HC | *** | +++ | Pink | Globose |
| | | | | | |
| Robinieae | | | | | |
| <i>Robinia pseudo-acacia</i> L. | STC | *** | + | Pink | Elongated |
| <i>Sesbania bispinosa</i> (Jacq.) | STC | *** | + | Pink | Globose |
| <i>S. concolor</i> Geillett | STC | *** | + | Pink | Globose |
| <i>S. grandiflora</i> (L.) Poir. | STC | *** | + | Pink | Globose |
| <i>S. sesban</i> (L.) Merrill | STC | *** | + | Pink | Globose |
| | | | | | |
| Trifolieae | | | | | |
| <i>Medicago aculeata</i> Willd. | HI | *** | + | Pink | Elongated |
| <i>Medicago arabica</i> (L.) Huds. | HI | *** | ++ | Pink | Elongated |
| <i>Medicago blanchiana</i> Boiss. | HI | *** | ++ | Pink | Elongated |
| <i>Medicago disciformis</i> DC. | HI | *** | +++ | Pink | Elongated |
| <i>Medicago falcata</i> L. | HW | *** | ++ | Pink | Elongated |
| <i>Medicago globosa</i> Presl. | HI | *** | + | Pink | Elongated |
| <i>Medicago intertexta</i> Mill. | HI | *** | ++ | Pink | Elongated |

| | | | | | |
|--|----|-----|-----|------|-----------|
| <i>Medicago littoralis</i> Lois. | HI | *** | +++ | Pink | Elongated |
| <i>Medicago lupulina</i> L. | HW | ** | +++ | Pink | Elongated |
| <i>Medicago murex</i> Willd. | HI | * | +++ | Pink | Elongated |
| <i>Medicago orbicularis</i> (L.) Bartal. | HW | * | ++ | Pink | Elongated |
| <i>Medicago polymorpha</i> L. | HC | * | ++ | Pink | Elongated |
| <i>Medicago reticulata</i> Benth. | HI | * | ++ | Pink | Elongated |
| <i>Medicago rigida</i> (L.) All. | HI | * | ++ | Pink | Elongated |
| <i>Medicago rotata</i> Bois. | HI | * | +++ | Pink | Elongated |
| <i>Medicago rugosa</i> Desr. | HI | * | +++ | Pink | Elongated |
| <i>Medicago sativa</i> L. | HC | * | +++ | Pink | Elongated |
| <i>Medicago scutellata</i> (L.) Mill. | HI | * | +++ | Pink | Elongated |
| <i>Medicago tornata</i> (L.) Mill. | HI | * | +++ | Pink | Elongated |
| <i>Medicago truncatula</i> Gaert. | HI | * | +++ | Pink | Elongated |
| <i>Medicago tribuloides</i> Desr. | HI | * | ++ | Pink | Elongated |
| <i>Medicago turbinata</i> (L.) All. | HI | * | +++ | Pink | Elongated |
| <i>Melilotus alba</i> Medik. | HW | * | +++ | Pink | Elongated |
| <i>Melilotus indica</i> (L.) All. | HW | * | +++ | Pink | Elongated |
| <i>Trifolium alexandrianum</i> L. | HC | *** | +++ | Pink | Elongated |
| <i>T. albopurpureum</i> Torr. & A. Gray | HW | ? | ++ | Pink | Elongated |
| <i>T. alpestre</i> L. | HI | * | + | Pink | Elongated |
| <i>T. barbigerum</i> Torr. | HW | ? | ++ | Pink | Elongated |
| <i>T. bifidum</i> Gray | HW | ? | ++ | Pink | Elongated |
| <i>T. campestre</i> Schreb. | HW | ? | ++ | Pink | Elongated |
| <i>T. ciliolatum</i> Benth. | HW | ? | ++ | Pink | Elongated |
| <i>T. cyathiferum</i> Lindl. | HW | ? | + | Pink | Elongated |
| <i>T. depauperatum</i> Desv. | HW | ? | ++ | Pink | Elongated |
| <i>T. dubium</i> Sibth. | HW | ? | + | Pink | Elongated |
| <i>T. fragiferum</i> L. | HC | ** | ++ | Pink | Elongated |
| <i>T. fucatum</i> Lindl. | HW | ? | + | Pink | Elongated |
| <i>T. gracilentum</i> Torr. & A. Gray | HW | * | + | Pink | Elongated |
| <i>T. hirsutum</i> All. | HC | ** | ++ | Pink | Elongated |
| <i>T. incarnatum</i> L. | HI | * | ++ | Pink | Elongated |
| <i>T. microcephalum</i> Pursh | HW | ? | + | Pink | Elongated |
| <i>T. microdon</i> Hook. & Arn. | HW | ? | + | Pink | Elongated |
| <i>T. pauciflorum</i> Nutt. | HW | ? | + | Pink | Elongated |
| <i>T. pratense</i> L. | HC | *** | +++ | Pink | Elongated |
| <i>T. repens</i> L. | HC | *** | +++ | Pink | Elongated |
| <i>T. resupinatum</i> L. | HW | * | +++ | Pink | Elongated |
| <i>T. subterraneum</i> L. | HC | *** | +++ | Pink | Elongated |
| <i>T. variegatum</i> Nutt. | HW | * | ++ | Pink | Elongated |
| <i>T. willdenovii</i> Spreng. | HW | ? | + | Pink | Elongated |
| | | | | | |
| | | | | | |

| Vicieae | | | | | |
|----------------------------------|----|-----|-----|------|-----------|
| <i>Lathyrus sativus</i> L. | VC | ** | ++ | Pink | Elongated |
| <i>Lens culinaris</i> Medik. | HC | ** | +++ | Pink | Elongated |
| <i>Vicia faba</i> L. | HC | *** | +++ | Pink | Elongated |
| <i>V. hirsuta</i> (L.) S.F. Gray | HW | * | +++ | Pink | Elongated |
| <i>V. sativa</i> L. | HW | * | ++ | Pink | Elongated |
| <i>V. villosa</i> Roth. | HW | * | ++ | Pink | Elongated |

¹Species are arranged alphabetically within genera.

²Legume type: H = herb; S = shrub; T = tree; V = vine or climber; C = cultivated; W = wild; I = introduced

³Forage value (Empirical scale of Brewbaker 1985).

*** Excellent; fodder species of wide and high value.

** Good; species that are used and deserve research.

* Fair; species that are used despite difficulties of use, quality, and management.

? Forage value questionable or not known.

⁴Nodulating status.

- Indicates no nodules.

+ Indicates 1 to 5 nodules per plant.

++ Indicates 6 to 10 nodules per plant.

+++ Indicates more than 10 nodules per plant.

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